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Nakayama

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(54) **SHEET CONVEYER AND IMAGE READING APPARATUS**

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This patent is subject to a terminal disclaimer.

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(30) **Foreign Application Priority Data**

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B65H 3/52 (2006.01)
B65H 7/02 (2006.01)

(52) **U.S. Cl.**
CPC ***B65H 7/12*** (2013.01); ***B65H 3/5238*** (2013.01); ***B65H 7/125*** (2013.01);
(Continued)

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CPC B65H 7/12; B65H 7/125; B65H 2553/30
USPC 271/262, 263, 265.04, 110, 111, 171; 250/559.27
See application file for complete search history.

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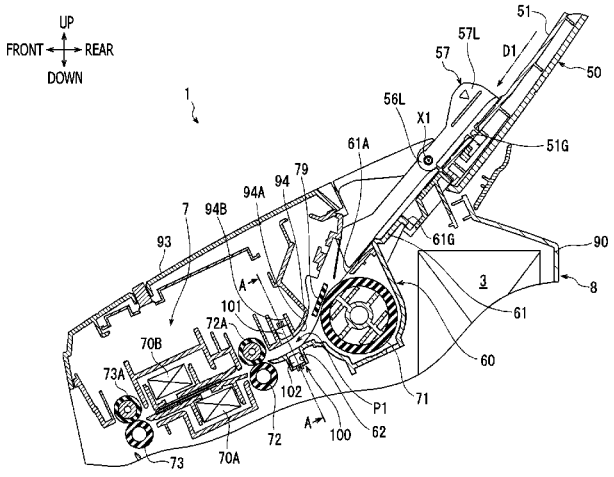
(57) **ABSTRACT**

A sheet conveyer, including a first roller to rotate to convey a sheet in a conveying direction; a separator arranged to be opposed to the first roller and configured to nip the sheet and to separate the sheet from other sheets; a multiple sheet sensor arranged in a downstream position with respect to the first roller and configured to sense presence of multiple sheets, the multiple sheet sensor including an emitter and a receiver; and a second roller arranged in a downstream position with respect to the multiple sheet sensor and configured to convey the separated sheet, is provided. A component being at least one of the emitter and the receiver is arranged in an outer side position with respect to the separator, and at least a part of the component is arranged in an inner side position with respect to the second roller.

24 Claims, 8 Drawing Sheets



(52) **U.S. Cl.**
CPC *B65H 2553/30* (2013.01); *B65H 2402/441* (2013.01); *B65H 2402/46* (2013.01); *B65H 2405/324* (2013.01); *B65H 2407/51* (2013.01); *B65H 2553/82* (2013.01); *B65H 2801/12* (2013.01); ***B65H 7/02*** (2013.01)

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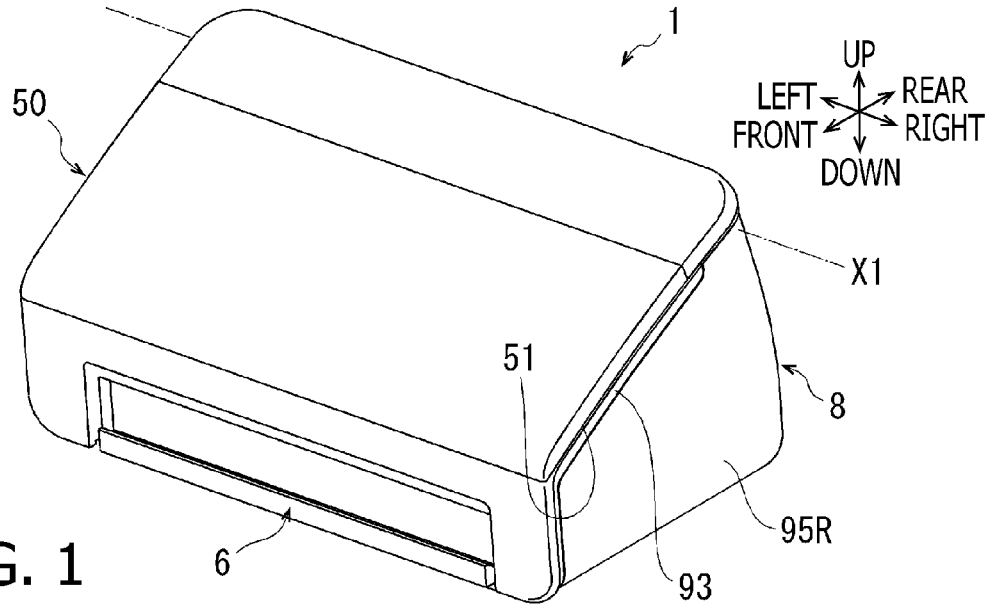
1
UP
LEFT
REAR
FRONT
RIGHT
DOWN
50
X1
51
8
95R
6
93

FIG. 1

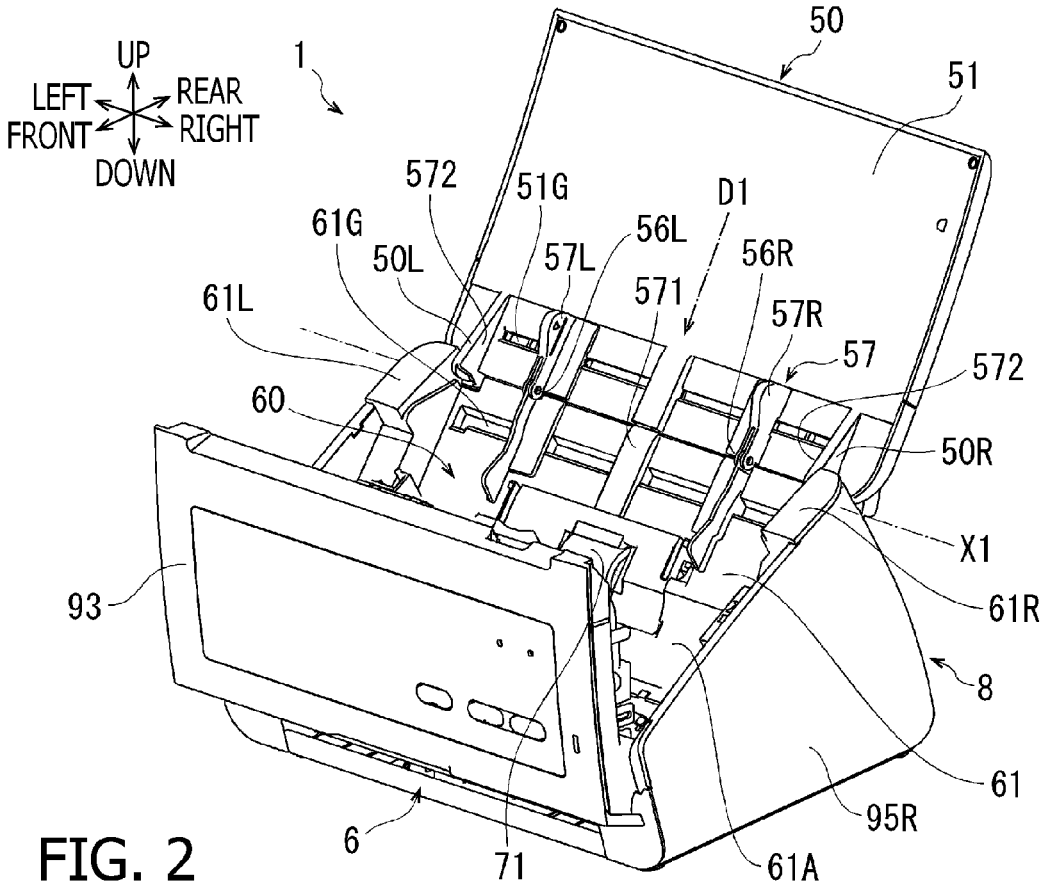
UP
LEFT
REAR
FRONT
RIGHT
DOWN
1
50
51
572
51G
D1
61G
56L
50L
57L
56R
571
61L
57R
57
572
60
50R
X1
93
61R
8
61
95R
6
71
61A

FIG. 2

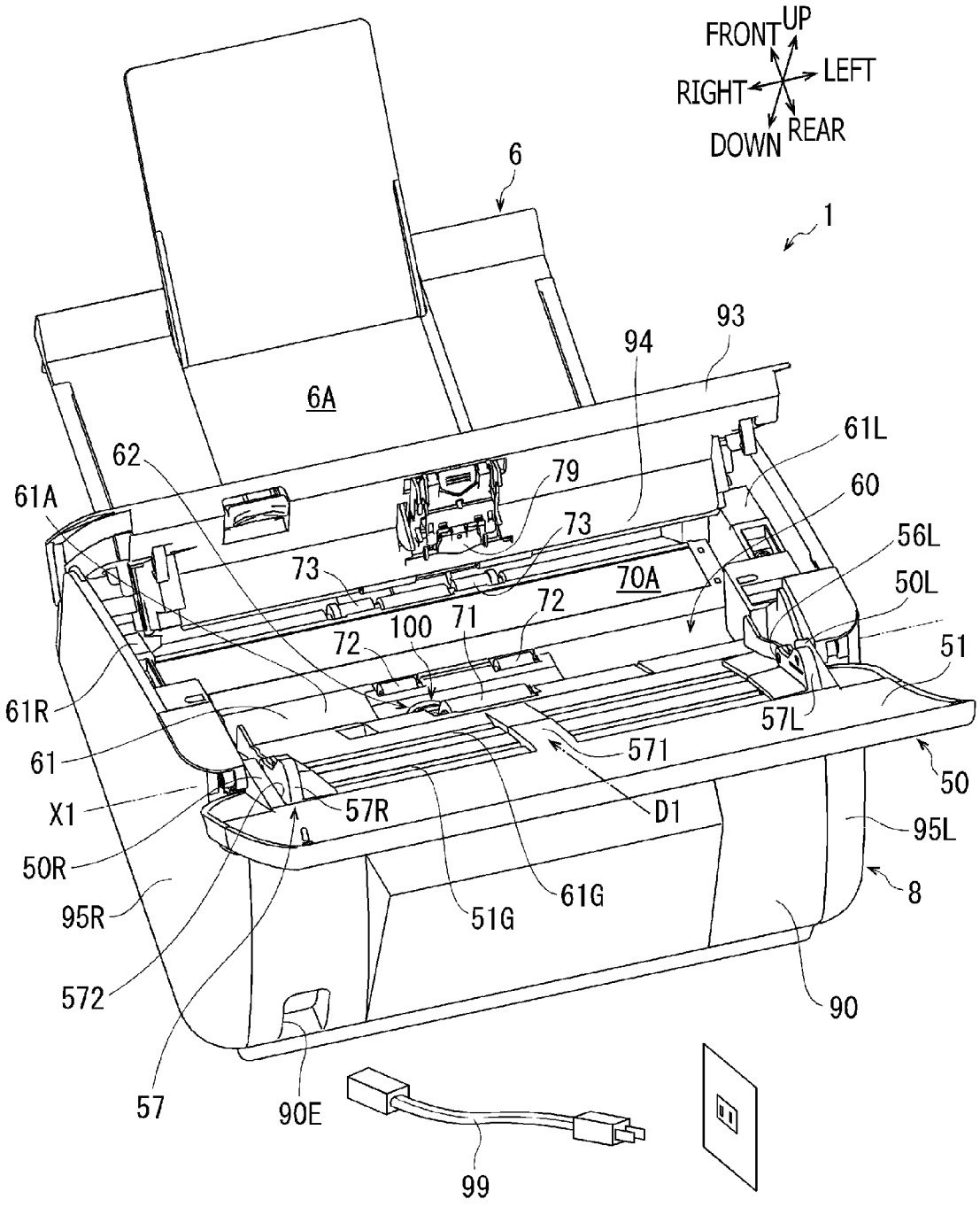
FRONT
UP
LEFT
RIGHT
DOWN
REAR
6
1
6A
93
94
61L
62
79
60
61A
73
56L
73
70A
50L
72
100
71
72
51
61R
57L
61
571
50
X1
57R
D1
95L
50R
8
95R
51G
61G
572
90
57
90E
99

FIG. 3

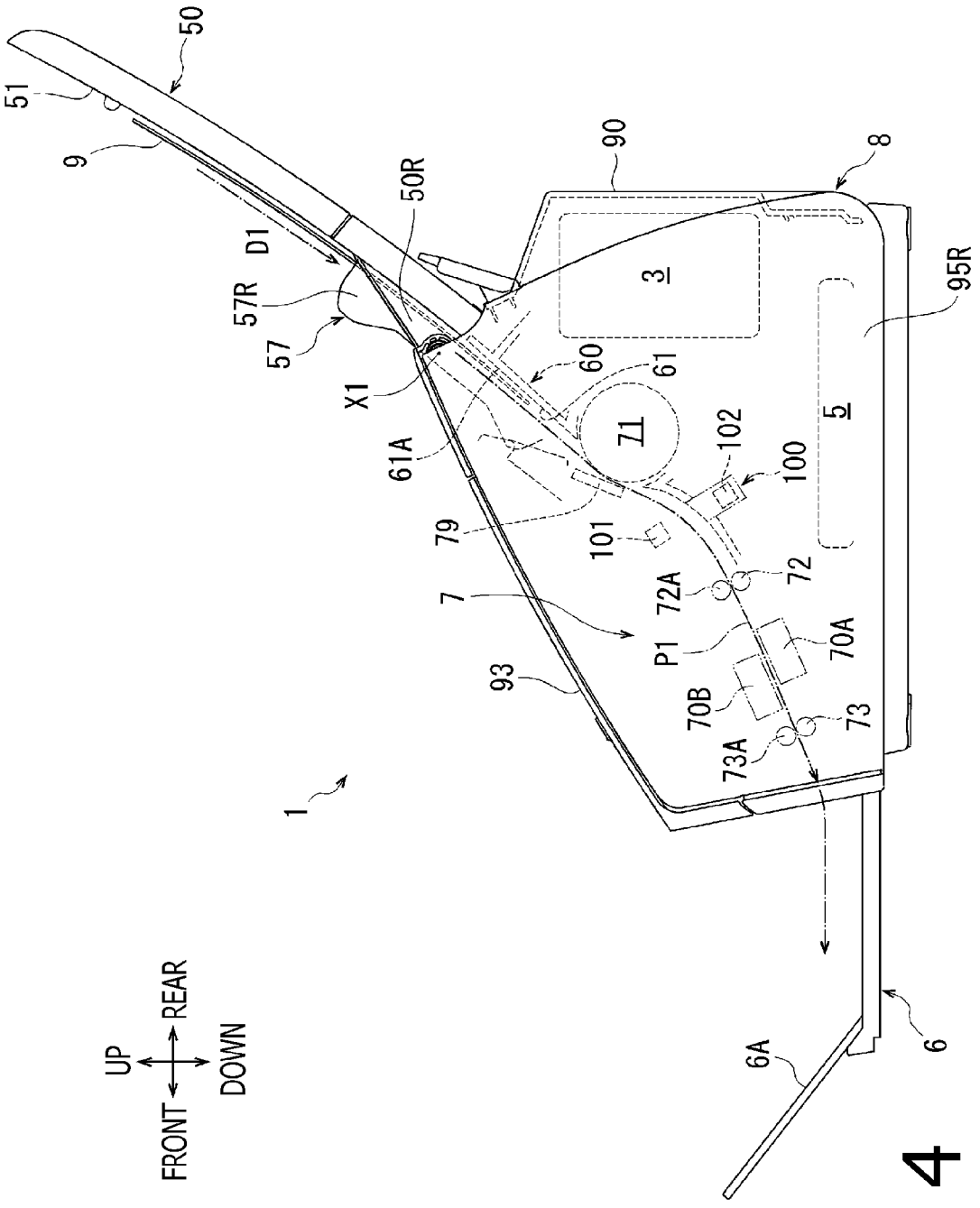
50
51
9
D1
50R
90
8
95R
3
57R
57
X1
60
61
71
5
61A
102
100
79
101
72
7
72A
P1
70A
93
70B
73
73A
1
6A
6
UP
REAR
FRONT
DOWN

FIG. 4

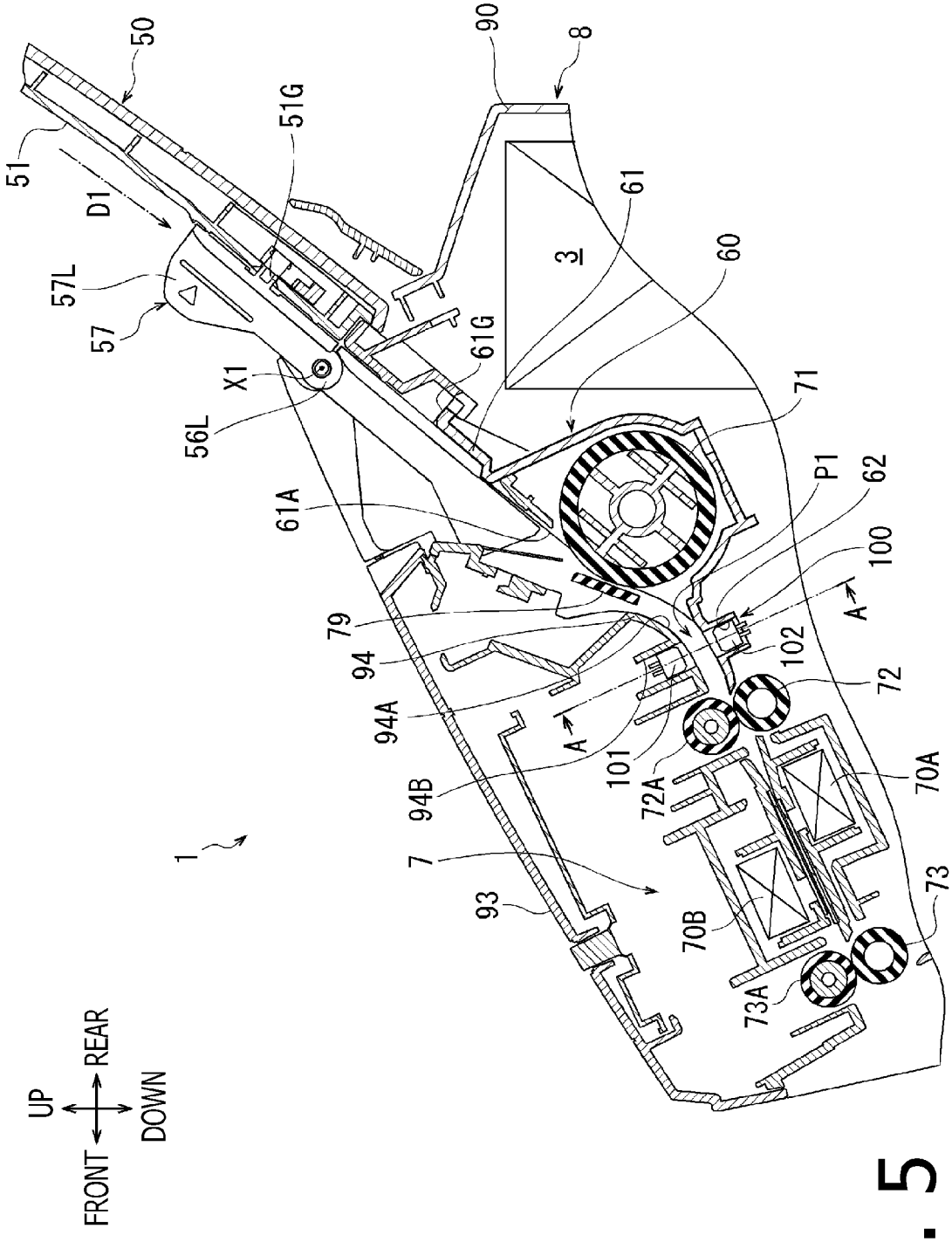
50
51
51G
D1
57L
57
56L
X1
90
8
61
3
60
61G
71
P1
62
61A
100
A
79
94
102
72
94A
A
101
72A
70A
94B
7
93
70B
73
73A
1
UP
REAR
FRONT
DOWN

FIG. 5

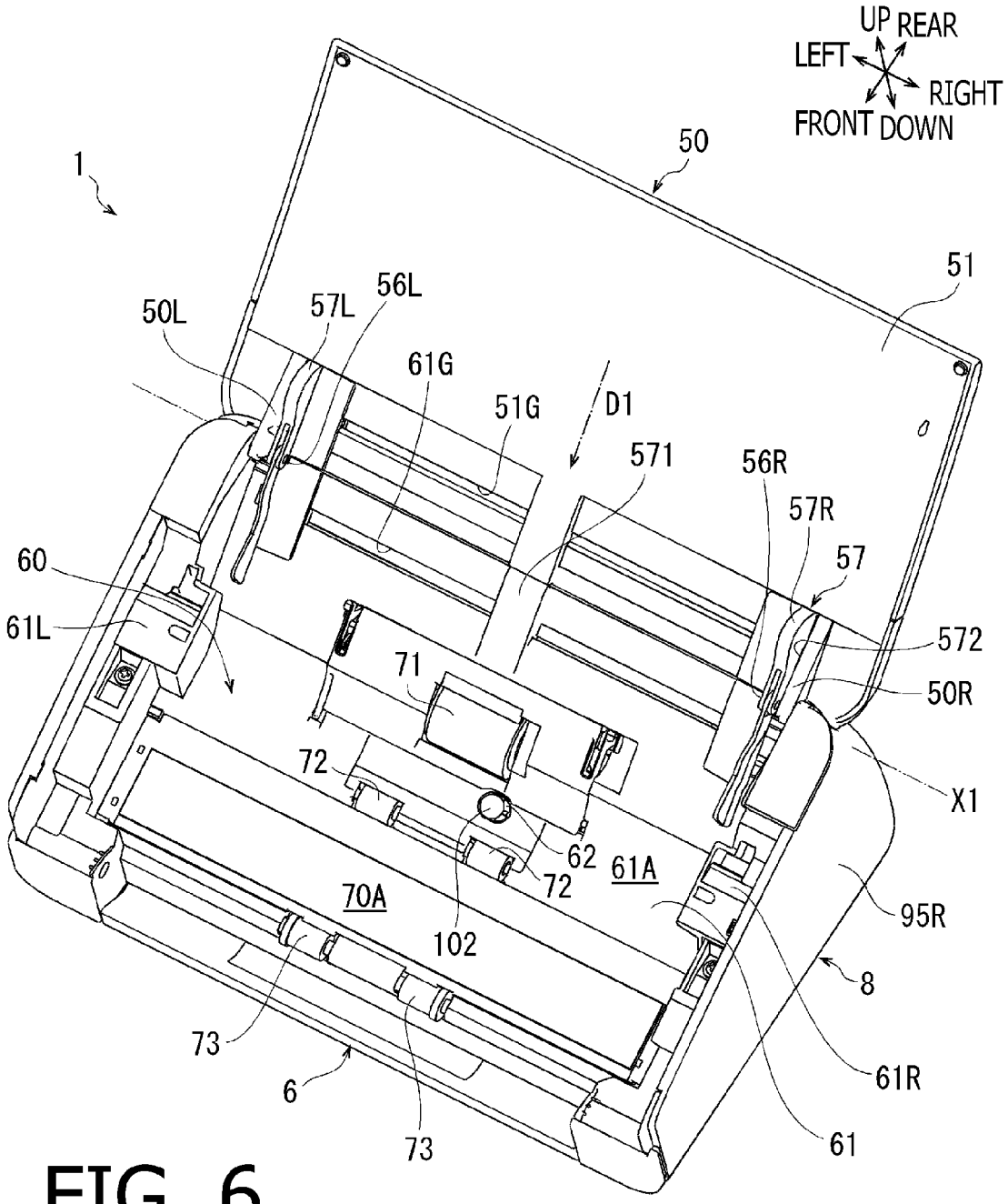
UP
REAR
LEFT
RIGHT
FRONT
DOWN
1
50
51
50L
57L
56L
61G
51G
D1
571
56R
57R
57
60
61L
572
71
50R
72
X1
62
61A
72
70A
95R
102
8
73
61R
6
73
61

FIG. 6

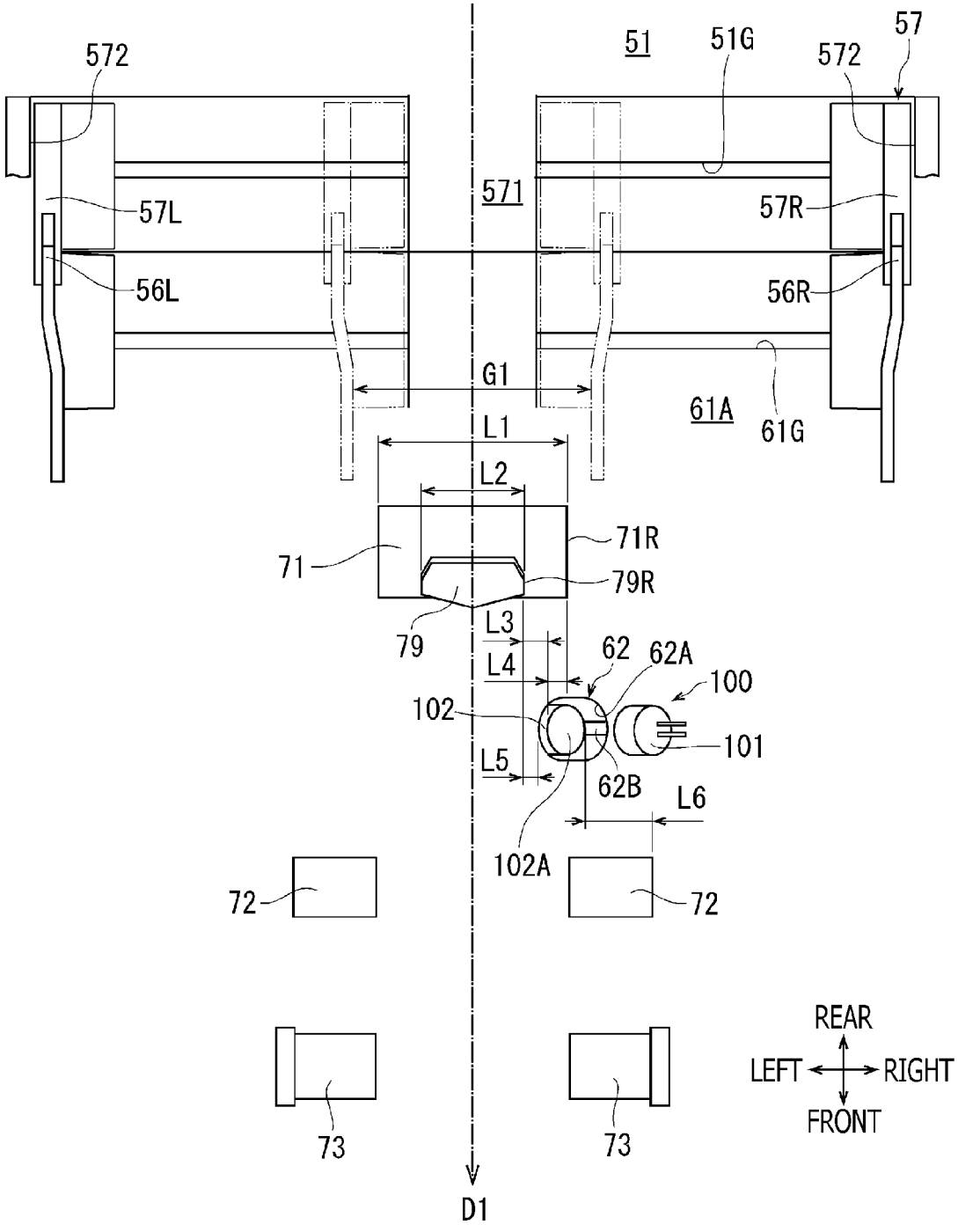
572
51
51G
572
57
57L
571
57R
56L
56R
G1
61A
61G
L1
L2
71
71R
79R
79
L3
62
62A
100
L4
102
101
L5
62B
L6
102A
72
72
73
73
REAR
LEFT
RIGHT
FRONT
D1

FIG. 7

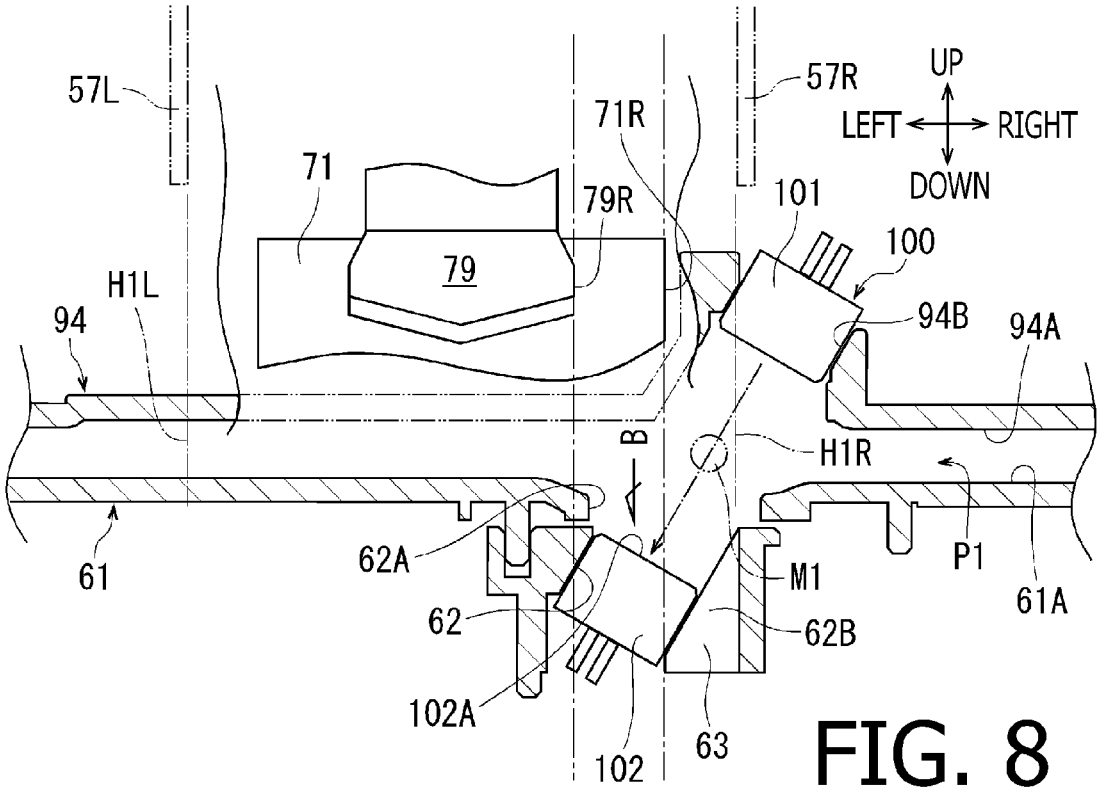
57L
57R
UP
LEFT
RIGHT
DOWN
71R
71
79R
101
100
79
H1L
94
94B
94A
B
H1R
61
62A
M1
P1
61A
62
62B
102A
102
63

FIG. 8

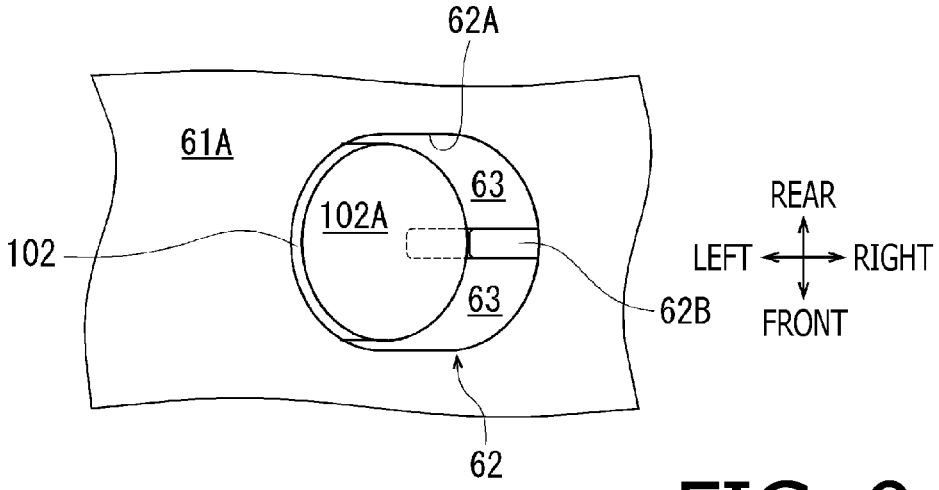
62A
61A
63
102A
REAR
LEFT
RIGHT
102
62B
63
FRONT
62

FIG. 9

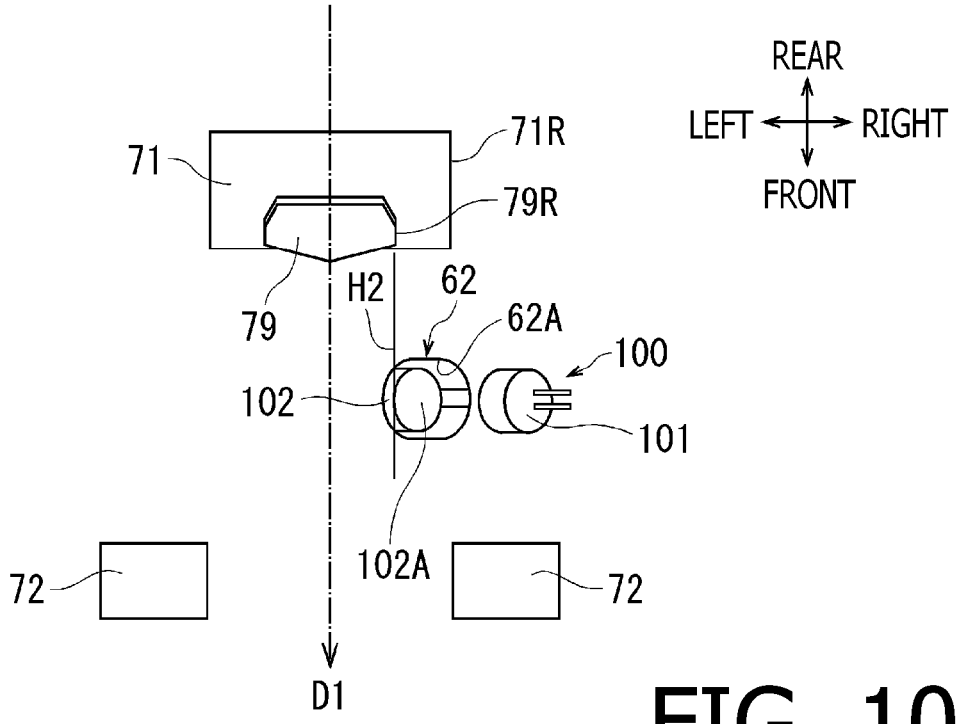
REAR
LEFT
RIGHT
FRONT
71
71R
79R
79
H2
62
62A
100
102
101
102A
72
72
D1

FIG. 10

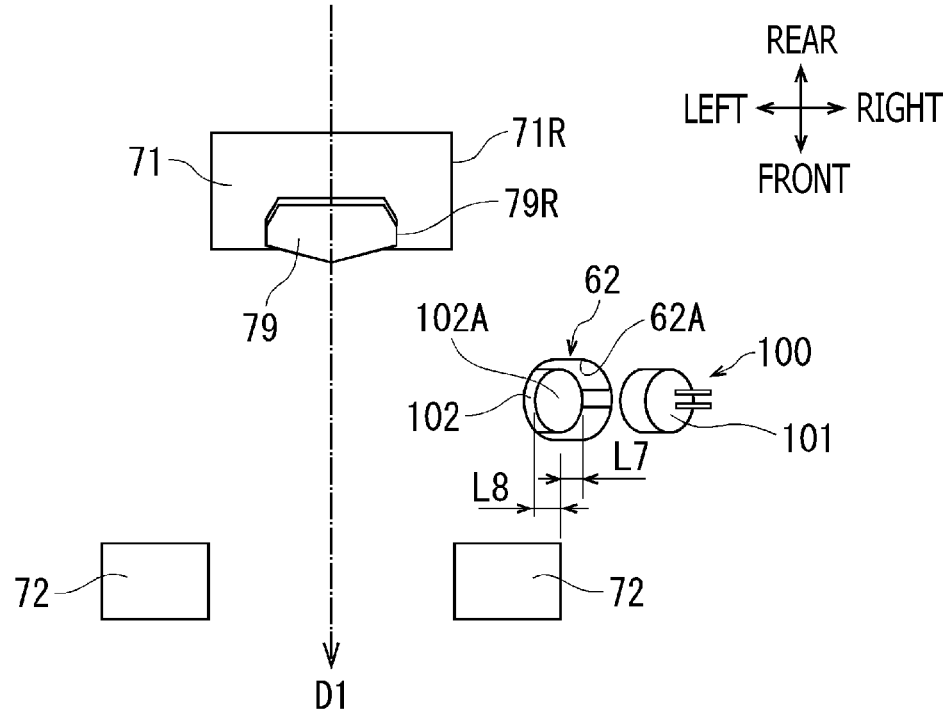
REAR
LEFT
RIGHT
FRONT
71
71R
79R
79
62
102A
62A
100
102
101
L7
L8
72
72
D1

FIG. 11

SHEET CONVEYER AND IMAGE READING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 13/630,241, entitled "Sheet Conveyor and Image Reading Apparatus," filed on Sep. 28, 2012, which application claims priority from Japanese Patent Application No. 2011-261470, filed on Nov. 30, 2011. The entire subject matter of each of these applications is incorporated herein by reference.

BACKGROUND

1. Technical Field

An aspect of the disclosure relates to sheet conveyers.

2. Related Art

A sheet conveyer conveys a sheet in a sheet conveyer path. The sheet conveyer may include a first roller, a separator arranged to be opposed to the first roller, and a multiple sheet sensor arranged in a downstream position with respect to the first roller along a sheet conveying direction. The multiple sheet sensor includes an emitter and a receiver.

In the sheet conveyer, the first roller feeds the sheet in the sheet conveying direction whilst rotating with the sheet being in contact with the first roller. In this regard, the separator nips the sheet in cooperation with the first roller and may separate the sheet from other sheets in a stack. The multiple sheet sensor thereafter detects presence of multiple sheets, that is, whether the sheet being conveyed by the first roller is correctly separated and fed one-by-one in the sheet conveyer path.

SUMMARY

In the sheet conveyer, whilst the sheets of paper are conveyed serially in the sheet conveyer path, paper dust may be produced by friction, which can be caused between the sheets and between the sheet and the separator. The dust may float and travel within the sheet conveyer along with the sheet in the sheet conveying direction toward a downstream of the flow of the sheet beyond the first roller. The dust may then adhere to the emitter and the receiver in the multiple sheet sensor and affect accuracy of the multiple sheet sensor undesirably. In other words, the dust may lower the accuracy of the multiple sheet sensor.

An aspect of the present disclosure may be advantageous in that sheet conveyers, in which the accuracy of detecting the presence of multiple sheets is prevented from being lowered, are provided.

According to an aspect of the disclosure, a sheet conveyer configured to convey a sheet in a conveyer path may include a first roller, a separator, a multiple sheet sensor, and a second roller. The first roller may be configured to contact the sheet and rotate to convey the sheet in a conveying direction. The separator may be arranged to be opposed to the first roller and configured to nip the sheet in cooperation with the first roller and to separate the sheet from other sheets. The multiple sheet sensor may be arranged in a downstream position in the conveying direction with respect to the first roller and configured to sense presence of multiple sheets. The multiple sheet sensor may include an emitter and a receiver. The second roller may be arranged in a downstream position in the conveying direction with respect to the multiple sheet sensor and configured to convey the separated sheet. A component being at least one of the emitter and the receiver may be arranged in an outer side position with respect to the separator along a widthwise direction, which is orthogonal to the conveying direction. At least a part of the component may be arranged in an inner side position with respect to the second roller along the widthwise direction.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

FIG. **1** is a perspective view of an image reading apparatus **1** showing a front face.

FIG. **2** is a perspective view of the image reading apparatus **1** showing the front face with a feeder tray **50** and an upper cover **93** being open.

FIG. **3** is a perspective view of the image reading apparatus **1** showing a rear face with the feeder tray **50**, the upper cover **93**, and a discharge tray **6** being open.

FIG. **4** is a side view of the image reading apparatus **1**.

FIG. **5** is a partially enlarged cross-sectional side view of the image reading apparatus **1**.

FIG. **6** is a perspective upper-side view of the image reading apparatus **1** with the feeder tray **50** being open and the upper cover **93** being removed.

FIG. **7** is a diagram to illustrate positional relation amongst a width-position guide **57**, a feed roller **71**, a multiple sheet sensor **100**, and conveyer rollers **72** in the image reading apparatus **1**.

FIG. **8** is a partially enlarged cross-sectional view of the image reading apparatus **1** taken along a line A-A shown in FIG. **5**.

FIG. **9** is a partially enlarged view of a receiver **102** and a sensor housing hole **62** for the multiple sheet sensor **100** of the image reading apparatus **1** taken along a direction indicated by an arrow B in FIG. **8**.

FIG. **10** is a diagram to illustrate another example of the image reading apparatus **1**.

FIG. **11** is a diagram to illustrate still another example of the image reading apparatus **1**.

DETAILED DESCRIPTION

Hereinafter, an image reading apparatus **1** as an example embodiment of a sheet conveyer according to the disclosure will be described with reference to the accompanying drawings.

In the example embodiment described below, directions concerning the image reading apparatus **1** will be referred to based on orientations indicated by arrows shown in each drawing. For example, a viewer's lower-left side appearing in FIG. **1**, on which a discharge tray **6** is arranged, is referred to as a front face of the image reading apparatus **1**. An upper-right side in FIG. **1**, opposite from the front, is referred to as rear. A side, which corresponds to the viewer's upper-left side is referred to as a left-side face, and an opposite side from the left, which corresponds to the viewer's lower-right side, is referred to as a right-side face. The right-left direction of the image reading apparatus **1** may also be referred to as a crosswise or lateral direction. The up-down direction in FIG. **1** corresponds to a vertical direction of the image reading apparatus **1**.

Detailed Configuration of the Image Reading Apparatus **1**

As shown in FIGS. **1-4**, the image reading apparatus **1** includes a chassis **8**, a feeder tray **50**, and a discharge tray **6**. Further, as shown in FIG. **4**, a conveyer path P**1**, in which a sheet **9** is conveyed from the feeder tray **50** to the discharge tray **6**, is formed in the image reading apparatus **1**.

The chassis **8** constitutes a box-shaped main body of the image reading apparatus **1** and includes an upper cover **93** forming an upper face of the chassis **8**, a rear cover **90** forming a rear face of the chassis **8**, and lateral covers **95**R, **95**L, forming lateral (right and left) faces of the chassis **8**. The chassis **8** further includes internal frames covered by the upper cover **93**, the rear cover **90**, and the lateral covers **95**R, **95**L. The internal frames include a lower chute **60** (see FIGS. **3** and **5**) and additional frames (not shown), which are assembled together.

As shown in FIG. **5**, the upper cover **93** is formed in a shape of a plane panel, which is arranged to incline upward from the front face toward the rear face of the chassis **8** over the lower chute **60**. The upper cover **93** includes an upper guide **94**, which faces the lower chute **60** from above. A lower side of the upper guide **94** provides an upper guide plane **94**A being a top plane of the conveyer path P**1**. As shown in FIGS. **2** and **3**, the upper cover **93** is swingable to uplift a rear end thereof upward and separated from the lower chute **60**. Thus, when, for example, a user needs to handle a sheet jam or other maintenance operations, the user can access a lower guide **61** being a bottom of the lower chute **60**, a feed roller **71**, or conveyer rollers **72** by uplifting the upper cover **93**.

The feeder tray **50** is formed in a thin plate, one side of which is configured to serve as a placement surface **51**. On right-side and left-side corners of the feeder tray **50**, hinges **50**R, **50**L are integrally formed. The feeder tray **50** is swingably supported by the chassis **8** to swing about a swing axis S**1**, which extends in a crosswise direction at an upper rear position in the chassis **8**, via the hinges **50**R, **50**L.

As shown in FIG. **1**, when in a closed posture, the feeder tray **50** is placed over the upper cover **93** with the placement surface **51** facing downward. The position of the feeder tray **50** in the closed posture shown in FIG. **1** will be referred to as "housed position."

When being rotated about the swing axis X**1**, as shown in FIGS. **2**-**6**, the feeder tray **50** is moved to a rearward position with respect to the chassis **8** and into an open posture, in which the placement surface **51** faces upward. The position of the feeder tray **50** in the open posture as shown in FIG. **2** will be referred to as "usable position."

When the feeder tray **50** is in the usable position, the sheet **9** can be placed on the placement surface **51** and can be conveyed from the placement surface **51** frontward along a conveying direction D**1** toward the discharge tray **6** (see FIG. **4**).

In this regard, the direction of width of the sheet **9** ("sheet-width") being conveyed in the conveying direction D**1** coincides with the crosswise (lateral) direction of the image reading apparatus **1**. Further, an "inner side" in the sheet-width refers to a side closer to a widthwise center of the sheet **9** being conveyed. Meanwhile, an "outer side" along the direction of sheet-width refers to a side farther from the widthwise center of the sheet **9** being conveyed.

As shown in FIG. **6**, the lower chute **60** includes a lower guide **61**, which is formed in a shape of a flat panel, and lateral walls **60**R, **60**L, which have the lower guide **61** interposed in a midst position there-between. The lower guide **61** spreads in parallel with the crosswise direction and extends in an angled posture to decline from a position in the vicinity of the swing axis X**1** on the rear side toward the discharge tray **6** on the front side. As shown in FIG. **5**, an upper surface of the lower guide **61** faces the upper guide plane **94**A of the upper cover **93** from a lower position across the conveyer path P**1**. An upper plane of the lower guide **61** support a lower side of the sheet **9** being conveyed from below and serves as a bottom plane **61**A of the conveyer path P**1**. As shown in FIG. **6**, when the feeder tray **50** is in the usable position, the bottom plane **61**A provides an inclined surface in continuity with the placement surface **51**.

As shown in FIG. **6**, the image reading apparatus **1** further includes a width-position guide **57**, which serve to place the sheet **9** in a correct crosswise position on the placement surface **51**. The width-position guide **57** includes a pair of rib-shaped guide pieces **57**R, **57**L, which are arranged in line-symmetrical crosswise (right and left) positions with each other. The guide pieces **57**R, **57**L extend in parallel with the conveying direction D**1** from an upper end of the placement surface **51** to the bottom plane **61**A. Each of the guide pieces **57**R, **57**L is formed to have a joint **56**R, **56**L in a longitudinally (along the conveying direction D**1**) midst position. The joints **56**R, **56**L allow the guide pieces **57**R, **57**L to be folded or to align straight by rotating about the swing axis X**1** when the feeder tray **50** is moved from the housed position to the usable position, and vice versa.

On the placement surface **51** and the bottom plane **61**A, guide rails **51**G, **61**G being narrow grooves extending in the crosswise direction are formed. The guide pieces **57**R, **57**L are engaged with the guide rails **51**G, **61**G and slidable in the crosswise direction with reference to the crosswise center on the placement surface **51** and the bottom plane **61**A to be close to or apart away from each other. The placement surface **51** and the bottom plane **61**A are formed to have a first restricting portion **571** on the widthwise center thereof. The first restricting portion **571** is a protrusion extending along the conveying direction D**1**. On laterally outer sides of the guide rails **51**G, **61**G, second restricting portions **572**, which are lateral walls of the hinges **50**R, **50**L, are formed to face each other.

As indicated by double-dotted dashed lines in FIG. **7**, the guide pieces **57**R, **57**L may be placed in mutually closest positions, in which a crosswise distance between the guide pieces **57**R, **57**L is the smallest, whilst lateral edges of the first restricting portion **571** are contacted by the guide pieces **57**R, **57**L. In other words, the guide pieces **57**R, **57**L cannot be moved closer to each other beyond the first restricting portion **571**. Therefore, when the guide pieces **57**R, **57**L are in the closest positions, the sheet **9**, even smaller-sized sheets **9** such as a business card and a letter sheet, can be placed on a laterally correct position with reference to the widthwise center on the placement surface **51** and the bottom plane **61**A as long as the smaller-sized sheet **9** fits in the smallest distance between the guide pieces **57**R, **57**L.

Meanwhile, as indicated in solid lines in FIG. **7**, the guide pieces **57**R, **57**L may be placed in mutually farthest positions, in which the crosswise distance between the guide pieces **57**R, **57**L is the largest with outer side planes of the guide pieces **57**R, **57**L being in contact with the second restricting portions **572** respectively. Therefore, when the guide pieces **57**R, **57**L are in the farthest positions, the sheet **9**, even a sheet **9** in a maximum allowable size (e.g., A4 size or legal size), can be placed on a laterally correct position with reference to the widthwise center on the placement surface **51** and the bottom plane **61**A as long as the large-sized sheet **9** fits in the farthest distance between the guide pieces **57**R, **57**L.

As shown in FIGS. **1**, **3**, and **4**, the discharge tray **6** can be stored in or drawn out of the chassis **8**. When the discharge tray **6** is stored in the chassis **8** (see FIG. **1**), the discharge tray **6** is exposed only at a front end of the discharge tray **6**. When the discharge tray **6** is drawn out of the chassis **8** (see FIGS. **3** and **4**), the discharge tray **6** can be placed in a posture to have a discharge surface **6**A facing upward in a frontward position with respect to the chassis **8**.

The image reading apparatus **1** further includes a power unit **3**, a control board **5**, and a reader unit **7** inside the chassis **8** (see FIGS. **4** and **5**).

As shown in FIG. **4**, the power unit **3** is disposed inside the chassis **8** on a side closer to the rear face of the chassis **8**. The power unit **3** is an alternate current adaptor, which converts alternate current from an electricity outlet into direct current and supply the electricity to the reader unit **7**. A rear side of the power unit **3** is covered by the rear cover **90**. As shown in FIG. **3**, on the rear cover **90**, a connector hole **90**E is formed. In the connector hole **90**E, an end of an electricity cable **99** to electrically connect the power unit **3** with the electricity outlet is inserted.

As shown in FIG. **4**, the control board **5** is arranged in a lower position with respect to the power unit **3** in the chassis **8**. The control board **5** is electrically connected with the power unit **3** and the reader unit **7** by cables (not shown) to control behaviors of the reader unit **7**.

As shown in FIGS. **4** and **5**, the reader unit **7** includes a feed roller **71**, a separator pad **79**, a multiple sheet sensor **100**, a conveyer roller **72**, an image reading sensors **70**A, **70**B, and a discharge roller **73**, which are arranged in the above-mentioned order along the conveyer path P**1**, from upstream to downstream, in the conveyer direction D**1**. The feed roller **71** picks up and feeds the sheet **9** in the conveying direction D**1**. The separator pad **79** nips the sheet **9** in cooperation with the feed roller **71** and separates the sheet **9** from the other sheets. The conveyer roller **72** conveys the separated sheet **9** forward in the conveying direction D**1**. The multiple sheet sensor **100** includes an emitter **101** and a receiver **102**.

Positional relations amongst the feed roller **71**, the separator pad **79**, the emitter **101**, the receiver **102**, the conveyer roller **72**, and the discharge roller **73** arranged in the conveyer path P**1** along the conveying direction D**1** are illustrated in FIG. **7**. Further, in FIG. **7**, positional relation between the feed roller **71** and the width-positioning guide **57** is illustrated.

As shown in FIGS. **5**-**7**, the feed roller **71** is arranged in a downstream position with respect to the guide pieces **57**R, **57**L along the conveying direction D**1**. The feed roller **71** is attached to the lower chute **60** and is arranged on the lower guide **61** in the conveyer path P**1**. As shown in FIG. **7**, a crosswise length L**1** of the feed roller **71** is smaller than an amount of clearance G**1** between the guide pieces **57**R, **57**L in the closest position. However, the crosswise length L**1** of the feed roller **71** is substantially long to steadily convey even a smaller-sized sheet **9** being placed in the correct widthwise position. The feed roller **71** is driven to rotate by a driving unit (not shown) and feeds the sheet **9** in the conveying direction D**1** by being rotated whilst the sheet **9** placed on the placement surface **51** is in contact with the feed roller **71**.

As shown in FIGS. **3** and **5**-**7**, the separator pad **79** is attached to the upper cover **93** and is arranged on the upper guide **94** in the conveyer path P**1**. The separator pad **79** is a thin piece of frictional material, such as rubber or elastomer. As shown in FIG. **7**, a crosswise length L**2** of the separator pad **79** is smaller than the crosswise length L**1** of the feed roller **71**. However, the crosswise length L**2** of the separator pad **79** is substantially long to steadily separate the sheet **9** being fed by the feed roller **71**. As shown in FIG. **5**, the separator pad **79** is arranged in a position to face the feed roller **71** and urged against the feed roller **71** by a resilient member (not shown). Thereby, the separator pad **79** nips the sheet **9** in cooperation with the feed roller **71** and separates the sheet **9** from the other sheets, which may otherwise be fed in the conveyer path P**1** along with the sheet **9**.

As shown in FIGS. **5** and **7**, the emitter **101** and the receiver **102** of the multiple sheet sensor **100** are arranged in a downstream position with respect to the feed roller **71** and the separator pad **79** along the conveying direction D**1**. As shown in FIGS. **5** and **8**, the emitter **101** and the receiver **102** are arranged to vertically face each other across the conveyer path P**1**. In the cross sectional view shown in FIG. **8**, taken along the line A-A (see FIG. **5**), the feed roller **71** and the separator pad **79** are located on a farther side with respect to the upper guide **94** of the upper cover **93**. Therefore, the feed roller **71** and the separator pad **79** interfered with by the upper guide **94** should not be seen in FIG. **8**. However, in FIG. **8**, a part of the upper guide **94** is indicated in an imaginary line to show the positions of the feed roller **71** and the separator pad **79**.

As shown in FIG. **8**, the emitter **101** is housed in a emitter housing hole **94**B, which is formed to recess from the upper guide plane **94**A of the upper guide **94** in upper-rightward inclination. As shown in FIGS. **7** and **8**, the emitter **101** is disposed on a laterally outer side with respect to the feed roller **71** and the separator pad **79**. More specifically, the emitter **101** is disposed in a rightward spaced-apart position with respect to a right-side end **71**R of the separator roller **71** and a right-side end **79**R of the separator pad **19**.

Meanwhile, as shown in FIG. **8**, the receiver **102** is housed in a sensor housing hole **62**, which is formed to recess from the bottom plane **61**A of the lower guide **61** in lower-leftward inclined orientation. The receiver **102** has a receiver surface **102**A, which faces the emitter **101** and receives ultrasonic waves from the emitter **101**. The receiver surface **102**A is in a lower-leftward position with respect to the emitter **101** in a rightward-angled orientation.

As shown in FIGS. **7** and **8**, the receiver **102** is disposed in the laterally outer side position with respect to the separator pad **79**. More specifically, a left-side end of the receiver surface **102**A is spaced apart for a length L**3** to the right with respect to the right-side end **79**R of the separator pad **79**. Further, at least a part of the receiver **102** is located in a laterally inner position with respect to the feed roller **71**. More specifically, a left-side end of the receiver surface **102**A of the receiver **102** is spaced apart for a length L**4** to the left with respect to the right-side end **71**R of the feed roller **71**.

For the receiver **102**, except the receiver surface **102**A, adhesive dust hardly affects quality to receive the ultrasonic waves emitted from the emitter **101** in the receiver **102**. In other words, mainly the receiver surface **102**A is affected by the dust in terms of the accuracy for receiving the ultrasonic waves. Therefore, the positional relation of the receiver **102** with the separator pad **79**, the feed roller **71**, and the conveyer roller **72** is defined based on the position of the receiver surface **102**A.

As shown in FIGS. **7** and **8**, an edge **62**A of the sensor housing hole **62** facing the conveyer path P**1** is in a laterally outer side position with respect to the separator pad **79**. More specifically, a left-side end of the edge **62**A is spaced apart for a length L**5** to the right with respect to the left-side end **79**R of the separator pad **79**.

As shown in FIGS. **8** and **9**, in the sensor housing hole **62**, a support rib **62**B, which protrudes leftward and extends vertically, is formed on an inner right-hand side. As shown in FIG. **8**, the support rib **62**B is formed in a shape of a triangular wedge, when viewed along the front-rear direction, and supports the receiver **102** in the sensor housing hole **62** by an oblique side thereof. As shown in FIG. **9**, the support rib **62**B divides a right-side area with respect to the receiver **102** in the sensor housing hole **62** into two sections along the front-rear direction. The area formed on the right-hand side of the receiver **102** and partitioned by the support rib **62**B will be

referred to as a recessed section **63**, which is adjacent to the receiver **102** and recessed downward with respect to the edge **62**A.

The multiple sheet sensor **100** is a known ultrasonic wave sensor, which emits ultrasonic waves from the emitter **101** and receives the emitted ultrasonic waves in the receiver **102** under control of the control board **5**. If the sheet **9** is in the conveyer path P**1** when the ultrasonic waves are emitted from the emitter **101**, the ultrasonic waves transmit the sheet **9**, and the waves to be received in the receiver **102** attenuate to a specific level. In this regard, attenuation rate for the ultrasonic waves depends on a quantity of sheets **9** being conveyed in the conveyer path P**1**. In other words, when two or more sheets **9** are conveyed in the conveyer path P**1**, the ultrasonic waves attenuate largely compared to attenuation of the ultrasonic waves transmitting a single sheet **9**. The multiple sheet sensor **100** thus senses whether the sheet **9** being conveyed includes two or more sheets to detect the presence of multiple sheets based on the attenuation rate of the ultrasonic waves being received.

The guide pieces **57**R, **57**L in the closest position are indicated in double-dotted dashed lines in FIG. **8**. In FIG. **8**, further, a measurement point M**1**, in which the supersonic waves emitted from the emitter **101** toward the receiver **102** intersect the conveyer path P**1**, is indicated. The ultrasonic waves emitted from the emitter **101** transmit the sheet **9** being conveyed in the conveyer path P**1** at the measurement point M**1**. The measurement point M**1** is located in a crosswise position between the guide pieces **57**R, **57**L in the closest position (i.e., between auxiliary lines H**1**R, H**1**L, which are vertically extended from the guide pieces **57**R, **57**L).

As shown in FIGS. **5**-**7**, the conveyer roller **72** is arranged in a downstream position with respect to the multiple sheet sensor **100** along the conveying direction D**1**. The conveyer roller **72** includes two conveyer rollers, which are arranged to align the crosswise direction. The conveyer roller **72** is attached to the lower chute **60** and is arranged on the lower guide **61** in the conveyer path P**1**. The conveyer roller **72** is driven by a driving unit (not shown) and rotates synchronously with the feed roller **71**. As shown in FIG. **5**, in an upper position with respect to the conveyer roller **72**, a driven roller **72**A is arranged to vertically face the conveyer roller **72**. The driven roller **72**A is attached to the upper cover **93** and is arranged on the upper guide **94** in the conveyer path P**1**. The driven roller **72**A is urged against the conveyer roller **72** by a resilient member (not shown). Thereby, the conveyer roller **72** nips the sheet **9** in cooperation with the driven roller **72**A and rotates to convey the sheet **9** toward the downstream in the conveyer path P**1**.

As shown in FIG. **7**, the receiver **102** is disposed such that at least a part of the receiver **102** is located in a laterally inner position with respect to the conveyer roller **72**. More specifically, a right-side end of the receiver surface **102**A of the receiver **102** is spaced apart for a length L**6** to the left with respect to the right-side end **72**R of the conveyer roller **72**.

As shown in FIG. **5**, the image reading sensors **70**A, **70**B are arranged in downstream positions with respect to the conveyer roller **72** along the conveying direction D**1**. The image reading sensor **70**A is attached to the lower chute **60** and is arranged on the lower guide **61** in the conveyer path P**1**. The image reading sensor **70**B is attached to the upper cover **93** and is arranged on the upper guide **94** in the conveyer path P**1**. Thus, the image reading sensors **70**A, **70**B face each other vertically across the conveyer path P**1**. The image reading sensors **70**A, **70**B may be, for example, a contact image sensor (CIS) or a charge coupled device (CCD).

As shown in FIGS. **5**-**7**, the discharge roller **73** is arranged in a downstream position with respect to the image reading sensors **70**A, **70**B along the conveying direction D**1**. The discharge roller **73** includes two discharge rollers, which are arranged to align the crosswise direction. The discharge roller **73** is attached to the lower chute **60** and is arranged on the lower guide **61** in the conveyer path P**1**. The discharge roller **73** is driven by a driving unit (not shown) and rotates synchronously with the feed roller **71** and the conveyer roller **72**. As shown in FIG. **5**, in an upper position with respect to the discharge roller **73**, a driven roller **73**A is arranged to vertically face the discharge roller **73**. The driven roller **73**A is attached to the upper cover **93** and is arranged on the upper guide **94** in the conveyer path P**1**. The driven roller **73**A is urged against the discharge roller **73** by a resilient member (not shown). Thereby, the discharge roller **73** nips the sheet **9** in cooperation with the driven roller **73**A and rotates to convey the sheet **9** to the discharge tray **6**, which is in a downstream position with respect to the discharge roller **73** along the conveying direction D**1**.

Image Reading Operation

An image reading operation to read images appearing on the sheet **9** will be described below. When the operation starts, firstly, the feed roller **71** rotates under control of the control board **5** whilst the sheet **9** is nipped in between the feed roller **71** and the separator pad **79**. Thus, the sheet **9** on the placement surface **51** is picked up and fed in the conveyer path P**1** along the conveying direction D**1**. If multiple sheets are picked up in layer, solely one sheet **9** is separated from the others by the effect of friction force caused between the separator pad **79** and forwarded in the conveyer path P**1**.

Secondly, whilst the separated sheet **9** is conveyed in the conveyer path P**1** in the conveying direction D**1**, the multiple sheet sensor **100** detects whether the sheet **9** has been separated from the other sheets by the separator pad **79**. In other words, the multiple sheet sensor **100** detects the presence of multiple sheets, if any. If the multiple sheet sensor **100** detects the presence of multiple sheets, the control board **5** deals with the presence of multiple sheets by, for example, aborting the image reading operation and notifying the user of the presence of multiple sheets.

Thirdly, if presence of one sheet is detected, the conveyer roller **72** forwards the separated sheet **9** in the conveyer path P**1**, and the image reading sensors **70**A, **70**B read images appearing on the upper and lower sides of the sheet **9**. The sheet **9** is thereafter conveyed to be discharged in the discharge tray **6** by the discharge roller **73**.

Effects of the Present Disclosure

According to the image reading apparatus **1** described above, the receiver **102**, as being one of the paired emitter **101** and receiver **102**, is disposed in the laterally outer side position with respect to the separator pad **79** (see FIGS. **7** and **8**). More specifically, the left-side end of the receiver surface **102**A of the receiver **102** is spaced apart for the length L**3** to the right with respect to the right-side end **79**R of the separator pad **79**. Therefore, although paper dust may be produced due to the friction between the separator pad **79** and the sheet **9**, and the dust may flow toward the downstream in the conveying direction D**1** along with the sheet **9**, whilst the receiver surface **102**A is spaced apart to the right with respect to the separator pad **79** and may not be in a direct path for the dust, the receiver surface **102**A can be prevented from adherence of the dust.

Further, the receiver **102** is disposed in the position, in which at least a part of the receiver **102** is located in a laterally inner position with respect to the conveyer roller **72**. More specifically, the right-side end of the receiver surface **102**A of

the receiver **102** is spaced apart for the length L**6** to the left with respect to the right-side end **72**R of the conveyer roller **72**. In this arrangement, the sheet **9** can pass by the multiple sheet sensor **100** whilst the sheet **9** can be maintained tensioned between the feed roller **71**, which is in an upstream position with respect to the multiple sheet sensor **100** in the conveying direction D**1**, and the conveyer roller **72**, which is in a downstream position with respect to the multiple sheet sensor **100** in the conveying direction D**1**, over the multiple sheet sensor **100**. Therefore, the presence of multiple sheets can be clearly detected by the multiple sheet sensor **100**.

Thus, in the image reading apparatus **1** according to the present disclosure, accuracy of detecting the presence of multiple sheets can be prevented from being lowered.

Further, according to the image reading apparatus **1** described above, the receiver **102** is arranged on the lower guide **61**, which is disposed in the lower position with respect to the conveyer path P**1**. Meanwhile, the paper dust produced by the friction between the separator pad **79** and the sheet **9** may tend to move toward the lower guide **61**, which is in the lower position in the conveyer path P**1**. However, with the above-described arrangement, the receiver **102** is prevented from the dust adhering to the receiver surface **102**A.

Further, in the image reading apparatus **1** described above, at least a part of the receiver **102** is located in the laterally inner position with respect to the feed roller **71**. More specifically, the left-side end of the receiver surface **102**A of the receiver **102** is spaced apart for the length L**4** to the left with respect to the right-side end **71**R of the feed roller **71**. In this arrangement, whilst the sheet **9** being conveyed can be maintained tensioned over the multiple sheet sensor **100**, which is in a downstream position with respect to the feed roller **71** in the conveying direction D**1**. Therefore, the presence of multiple sheets can be clearly detected by the multiple sheet sensor **100**.

Further, in the image reading apparatus **1** described above, the sensor housing hole **62** is formed to recess downward from the lower guide plane **61**A of the lower guide **61** in lower-leftward inclination. The edge **62**A of the sensor housing hole **62** facing the conveyer path P**1** is in the laterally outer side position with respect to the separator pad **79**. More specifically, the left-side end of the edge **62**A is spaced apart for the length L**5** to the right with respect to the left-side end **79**R of the separator pad **79**. Thus, with the edge **62**A being displaced to the right with respect to the separator pad **79**, the receiver **102** may not be directly exposed to the flow of the dust and may be prevented from the dust adhering to the receiver surface **102**A.

Further, in the image reading apparatus **1** described above, the sensor housing hole **62** is formed to have the recessed section **63** (see FIG. **9**), which is adjacent to the receiver **102** and recessed downward with respect to the receiver **102**. Therefore, the dust flowing in the sensor housing hole **62** may tend to accumulate in the recessed section **63** and may be prevented from adhering to the receiver **102**.

Further, in the image reading apparatus **1** described above, the paired emitter **101** and the receiver **102** are arranged to face each other across the conveyer path P**1**. In this regard, the transmissive-typed sensor with the emitter **101** and the receiver **102** may be more accurately detect the presence of multiple sheets compared to a reflective-typed sensor. Thus, the accuracy of the multiple sheet sensor **100** may be relatively improved.

Further, in the image reading apparatus **1** described above, the emitter **101** is disposed in the laterally outer side position with respect to the receiver **102**. In this arrangement, the receiver **102** can be placed in a closest position to the separator pad **79**. Meanwhile, the emitter **101** can be disposed in the laterally outer side position to be spaced apart with respect to the separator pad **79** and the feed roller **71**. Therefore, open space may be created in areas between the emitter **101** and the separator pad **79** and between the emitter **101** and the feed roller **71**. Accordingly, the areas in the vicinities of the multiple sheet sensor **100** may be effectively utilized.

Further, in the image reading apparatus **1** described above, the measurement point M**1** is located in the crosswise position between the guide pieces **57**R, **57**L being in the closest position (i.e., between auxiliary lines H**1**R, H**1**L, which are vertically extended from the guide pieces **57**R, **57**L). In this arrangement, the presence of multiple sheets **9** even in a maximum allowable sheet-width can be detected.

Although an example of carrying out the disclosure have been described, those skilled in the art will appreciate that there are numerous variations and permutations of the sheet conveyer that fall within the spirit and scope of the disclosure as set forth in the appended claims. It is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or act described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

For example, the separator pad **79** may be replaced with a separator roller such as a retard roller.

For another example, the crosswise length between the left-side end of the receiver surface **102**A and the right-side end **79**R of the separator pad **79** may be zero. In other words, as shown in FIG. **10**, the left-side end of the receiver surface **102**A may be on an extended line H**2**, which extends from the right-side end **79**R of the separator pad **79** in parallel with the conveying direction D**1**.

For another example, a left-side part of the receiver **102** may be disposed in a laterally inner side with respect to the conveyer roller **72**. More specifically, as shown in FIG. **11**, the right-side end of the receiver **102**A may be spaced apart to the right for a length L**7** with respect to the right-side end **72**R of the conveyer roller **72**, and the left-side end of the receiver surface **102**A may be spaced apart to the left for a length L**8** with respect to the right-side end **72**R of the conveyer roller **72**.

For another example, the positions of the feed roller **71**, which is on the lower side with respect to the conveyer path P**1**, and the separator pad **79**, which is on the upper side with respect to the conveyer path P**1** to face the feed roller **71** from above, may be replaced with each other.

For another example, the positions of the receiver **102** and the emitter **101** may be replaced with each other. That is, the emitter **101** may be disposed in the sensor housing hole **62**, and the receiver **102** may be disposed in the housing hole **94**B, which is formed to recess from the upper guide plane **94**A of the upper guide **94**.

For another example, whilst the measurement point M**1** may be located in the position laterally between the guide pieces **57**R, **57**L being in the closest position, the emitter may not necessarily be disposed in the rightward position with respect to the guide piece **57**R. For example, the emitter **101** and the receiver **102** may be disposed in positions laterally between the guide pieces **57**R, **57**L being in the closest position. In this arrangement, the measurement point M**1** should easily fall in the position laterally between the guide pieces **57**R, **57**L being in the closest position.

For another example, the multiple sheet sensor **100** may not necessarily be a transmissive-typed ultrasonic wave sensor, with the emitter **101** and the receiver **102** being arranged to face each other across the conveyer path P**1**. For example, the multiple sheet sensor may be a reflective-typed ultrasonic

wave sensor, in which ultrasonic waves emitted from a emitter are reflected on the sheet in the conveyer path P1 and the reflected ultrasonic waves are received in the receiver. Further, the multiple sheet sensor may be an optical sensor, in which light is emitted from an emitter, and the light transmitting through the sheet or reflected on the sheet is received in a receiver.

The sheet conveyer described above may be applied to, for example, an image reading apparatus, an image forming apparatus or a multifunction device.

What is claimed is:

1. A sheet conveyer, comprising:
a first roller configured to convey a sheet in a first direction;
a separator arranged to be opposed to the first roller;
a second roller arranged in a downstream position in the first direction with respect to the first roller; and
a multiple sheet sensor arranged in a downstream position in the first direction with respect to the first roller and in an upstream position in the first direction with respect to the second roller, the multiple sheet sensor including a receiver and a paired emitter paired with the receiver, one of the receiver and the paired emitter being arranged at least partially in an outer side position with respect to the separator in a second direction, the one of the receiver and the paired emitter being arranged at least partially in an inner side position with respect to the second roller in the second direction, and the other one of the receiver and the paired emitter being arranged at least partially in an outer side position with respect to the separator in the second direction, wherein the second direction is orthogonal to the first direction.

2. The sheet conveyer according to claim 1, further comprising:
an upper guide; and
a lower guide spaced apart from the upper guide and arranged below the upper guide,
wherein the one of the receiver and the paired emitter is arranged in the lower guide, and the other one of the receiver and the paired emitter is arranged in the upper guide.

3. The sheet conveyer according to claim 2,
wherein the upper guide and the lower guide define a conveyer path therebetween; and
wherein the one of the receiver and the paired emitter is housed in a sensor housing hole, wherein the lower guide further defines the sensor housing hole recessing downwardly from the conveyer path.

4. The sheet conveyer according to claim 3,
wherein the sensor housing hole is inclined with respect to the second direction, an edge of the sensor housing hole being at least partially in an outer side position with respect to the separator along the second direction.

5. The sheet conveyer according to claim 3,
wherein the lower guide further defines a recessed section surrounding the sensor housing hole, wherein the recessed section is adjacent to the one of the receiver and the paired emitter and recesses downwardly.

6. The sheet conveyer according to claim 5,
wherein the recessed section partially surrounds the sensor housing hole.

7. The sheet conveyer according to claim 2,
wherein the upper guide and the lower guide define a conveyer path therebetween; and
wherein the receiver and the paired emitter in the multiple sheet sensor are arranged to be opposed to each other across the conveyer path.

8. The sheet conveyer according to claim 1,
wherein at least a part of the one of the receiver and the paired emitter is arranged in an inner side position with respect to the first roller along the second direction.

9. The sheet conveyer according to claim 1, further comprising:
a width-position guide configured to restrict a position of the sheet in the second direction, the width-position guide including a pair of guide members, which are arranged to be opposed to each other along the second direction, the guide members being configured to be placed in a closest position, in which a distance between the guide members is smallest, and to be placed in a farthest position, in which the distance between the guide members is largest, the guide members being movable between the closest position and the farthest position.

10. The sheet conveyer according to claim 9, wherein a measurement point, in which waves emitted from the paired emitter toward the receiver intersect with a conveyer path, is set in a position between the guide members placed in the closest position.

11. The sheet conveyer according to claim 1, further comprising:
a controller configured to determine whether multiple sheets have been fed or not based on a signal received from the multiple sheet sensor.

12. The sheet conveyer according to claim 1,
wherein the separator comprises a separation pad.

13. A sheet conveyer, comprising:
a first guide having a first surface;
a second guide having a second surface, the second surface facing and spaced apart from the first surface;
a first roller extending along the second surface;
a separator extending along the first surface and being opposed to the first roller;
a second roller extending along the second surface and spaced apart from the first roller in a first direction; and
a multiple sheet sensor arranged between the first roller and the second roller in the first direction, the multiple sheet sensor including a receiver and a paired emitter paired with the receiver, one of the receiver and the paired emitter being arranged at least partially in an outer side position with respect to the separator in a second direction, the one of the receiver and the paired emitter being arranged at least partially in an inner side position with respect to the second roller in the second direction, the one of the receiver and the paired emitter being arranged in the second guide, the other one of the receiver and the paired emitter being arranged at least partially in an outer side position with respect to the separator in the second direction, and the other one of the receiver and the paired emitter being arranged in the first guide, wherein the second direction is orthogonal to the first direction.

14. The sheet conveyer according to claim 13,
wherein the separator comprises a separation pad.

15. The sheet conveyer according to claim 13,
wherein the first surface of the first guide defines a sensor housing hole, the sensor housing hole recessing from the first surface, and
wherein the one of the receiver and the paired emitter is housed in the sensor housing hole.

16. The sheet conveyer according to claim 13,
wherein the first surface of the first guide and the second surface of the second guide define a conveyer path therebetween; and

wherein the receiver and the paired emitter in the multiple sheet sensor are arranged to be opposed to each other across the conveyer path.

17. An image reading apparatus, comprising:

a first roller configured to convey a sheet in a first direction;

a separator arranged to be opposed to the first roller;

an image reading sensor;

a second roller arranged between the first roller and the image reading sensor in the first direction; and

an ultrasonic wave sensor arranged between the first roller and the second roller, the ultrasonic wave sensor including a receiver and a paired emitter paired with the receiver, one of the receiver and the paired emitter being arranged in an outer side position with respect to the separator in a second direction, the one of the receiver and the paired emitter being arranged in an inner side position with respect to both ends of the second roller in the second direction, the one of the receiver and the paired emitter being arranged in an inner side position with respect to the image reading sensor in the second direction, the other one of the receiver and the paired emitter being arranged in an outer side position with respect to the separator in the second direction, and the other one of the receiver and the paired emitter being arranged in an inner side position with respect to the image reading sensor in the second direction, wherein the second direction is orthogonal to the first direction.

18. The image reading apparatus according to claim **17**, wherein the separator comprises a separation pad.

19. The image reading apparatus according to claim **17**, further comprising:

an upper guide; and

a lower guide spaced apart from the upper guide and arranged below the upper guide,

wherein the one of the receiver and the paired emitter is arranged in the lower guide, and the other one of the receiver and the paired emitter is arranged in the upper guide.

20. The image reading apparatus according to claim **19**,

wherein a first surface of the lower guide defines a sensor housing hole, the sensor housing hole recessing from the first surface, and

wherein the one of the receiver and the paired emitter is housed in the sensor housing hole.

21. The image reading apparatus according to claim **20**,

wherein the first surface of the lower guide and a second surface of the upper guide define a conveyer path therebetween, the second surface facing and spaced apart from the first surface; and

wherein the receiver and the paired emitter in the ultrasonic wave sensor are arranged to be opposed to each other across the conveyer path.

22. An image reading apparatus, comprising:

a first roller configured to convey a sheet in a first direction;

a separator arranged to be opposed to the first roller;

an image reading sensor;

a pair of second rollers arranged in a downstream position in the first direction with respect to the first roller, and in an upstream position in the first direction with respect to the image reading sensor;

a movable member arranged in an upstream position with respect to the first roller and configured to move in a second direction, the second direction being orthogonal to the first direction; and

an ultrasonic wave sensor arranged in a downstream position in the first direction with respect to the first roller, and in an upstream position in the first direction with respect to the second rollers, the ultrasonic wave sensor including a receiver and a paired emitter paired with the receiver, the receiver having a receiver surface facing the paired emitter,

wherein the receiver and the paired emitter are arranged such that:

the receiver surface of the receiver is laterally outward, in the second direction, of the separator;

the receiver surface is laterally inward, in the second direction, of an outer end of one of the pair of second rollers;

the receiver surface is laterally outward, in the second direction, of an inner end of the one of the pair of second rollers;

the receiver surface is at least partially laterally outward, in the second direction, of an outer end of the first roller; and

the one of the pair of second rollers and one of the receiver and the paired emitter are on a same side, in the second direction, of the first roller.

23. The image reading apparatus according to claim **22**, further comprising:

an upper guide; and

a lower guide spaced apart from the upper guide and arranged below the upper guide, wherein the receiver is arranged in the lower guide, and the paired emitter is arranged in the upper guide.

24. The image reading apparatus according to claim **23**, wherein the first roller, the second roller, and the image reading sensor are arranged in the lower guide and the separator is arranged in the upper guide.

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